



# LIGHTWEIGHT & ADVANCED MATERIALS FOR DEFENSE

Materials for Military Ground Vehicles



## Donald T. Ostberg

Lightweight Structures Team Leader  
U.S. Army Tank Automotive Research  
Development & Engineering Center

**TARDEC**  
U.S. ARMY TANK AUTOMOTIVE RESEARCH DEVELOPMENT AND ENGINEERING CENTER

SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

<b>Report Documentation Page</b>			Form Approved OMB No. 0704-0188	
<p>Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.</p>				
1. REPORT DATE <b>27 JUN 2006</b>	2. REPORT TYPE <b>N/A</b>	3. DATES COVERED <b>-</b>		
4. TITLE AND SUBTITLE <b>Material for Military Ground Vehicles</b>			5a. CONTRACT NUMBER	
			5b. GRANT NUMBER	
			5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) <b>Ostberg, Donald T.</b>			5d. PROJECT NUMBER	
			5e. TASK NUMBER	
			5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>U.S. Army TACOM 6501 E 11 Mile Road Warren, MI 48397-5000</b>			8. PERFORMING ORGANIZATION REPORT NUMBER <b>15959</b>	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S) <b>TACOM TARDEC</b>	
			11. SPONSOR/MONITOR'S REPORT NUMBER(S) <b>15959</b>	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release, distribution unlimited</b>				
13. SUPPLEMENTARY NOTES <b>Video mentioned in Brief is not included, The original document contains color images.</b>				
14. ABSTRACT				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>SAR</b>	18. NUMBER OF PAGES <b>18</b>
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>		



## Outline

Tactical Vehicles  
FCS Structure and Materials  
Advanced Reconfigurable Structure



## Materials for Tactical Trucks

Material must be readily available and fully developed.

- RHA
- High hard steel
- Aluminum

Research projects are ongoing to further develop advanced lightweight armors.

- Composites
- Ceramics
- Titanium

### Long Term Armor Strategy

- A + B design
- Requirements are classified





## Future Combat System (FCS) Materials

FCS requirements

C130 transportable

- Transport weight not to exceed 18.5 tons
- Weight can be increased on ground
- Dimensional constraints
- Structure "A" + Armor "B" solution
- Structure selected by IPT to be 5059 Aluminum with friction stir welded 2195 Aluminum/Lithium belly Cover layer
  - Fall back position 5083 Aluminum with friction stir welded 2195 Aluminum/Lithium belly
  - Fall back position 5059 complete structure Composite layer
- No selection yet for "B" armor

Cost

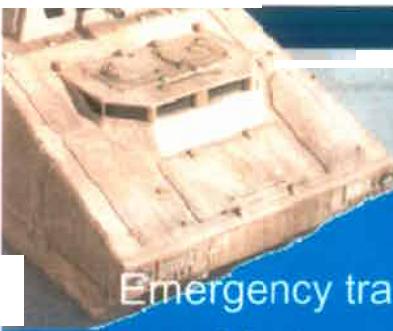


FCS Video



SUPERIOR TECHNOLOGY FOR A SUPERIOR ARMY

TARDEC



## FCS May 25 Guidance (+)

Emergency transport configuration

Maximum Size Envelope For Variants

- 119" Width
- 108" Height
- 263" Hull Length (excluding barrel overhang)

Unlimited time for ECC - FCC transition

C-130 ramp hinge limit

Use Non-Combat Configuration (NCC) approach for vehicle configuration

Use platform maintenance manuals as the guide for removal and reassembly

Shoring is allowed to solve rail and hinge issues

This initial guidance will  
be refined and updated if  
required NLT Jun 16



## Trade Process & Conduct

7

- This trade was conducted in accordance with the approved FCS trade study process
- The measures in the metallic material trade process will addressed:
  - Cost - measured in dollars
    - Raw Material, measured in dollars per kilogram
  - Integration Burdens & Allocations
    - Weight, measured in kilograms
  - Risk
    - Producibility
    - Performance
    - New Material Characterization Cost
  - Performance
    - Logistics
    - Corrosion Susceptibility
    - Mine Blast Resistance

*The IPT established weighting factors as part of the formal trade process.*



## Assumptions (1)

Trade is for metallic portion of MGV chassis only

• Trade Alternatives are:

- Aluminum 2519
- Aluminum 5083
- Aluminum 5059
- Aluminum 2519 with 2195 Al/Li friction Stir Welded Floor
- Aluminum 5083 with 2195 Al/Li friction Stir Welded Floor
- Aluminum 5059 with 2195 Al/Li friction Stir Welded Floor
- Aluminum 2519 with Ti Bolt in Floor
- Aluminum 5083 with Ti Bolt in Floor
- Aluminum 5059 with Ti Bolt in Floor

• Trade will evaluate a MGV point design (BTA1U with updates)

• Initial MGV configuration will be Carrier type vehicle (C2V) Initial study will be for an "A" + "B" armor integration approach where upper hull "A" has no ballistic requirement at ECC and lower side wall will work in concert with Skirt, minimum thickness to be 0.75 Al and a 4 mm. allowable deflection from lower side wall to the suspension.



# Hull Aluminum Material Trade Study Results and Hull IPT Recommendations

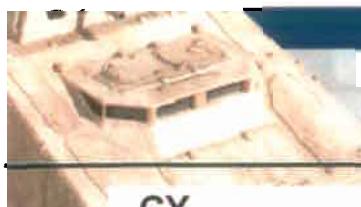
## Trade study results

- Aluminum hull material trade study winning candidates
  - 5059/2195 - Winner
  - 5083/2195 – Close 2nd
  - 5059 - Close 3<sup>rd</sup>
- Winning triad rankings robust and not susceptible to moderate weighting alterations
- High degree of Hull IPT consensus

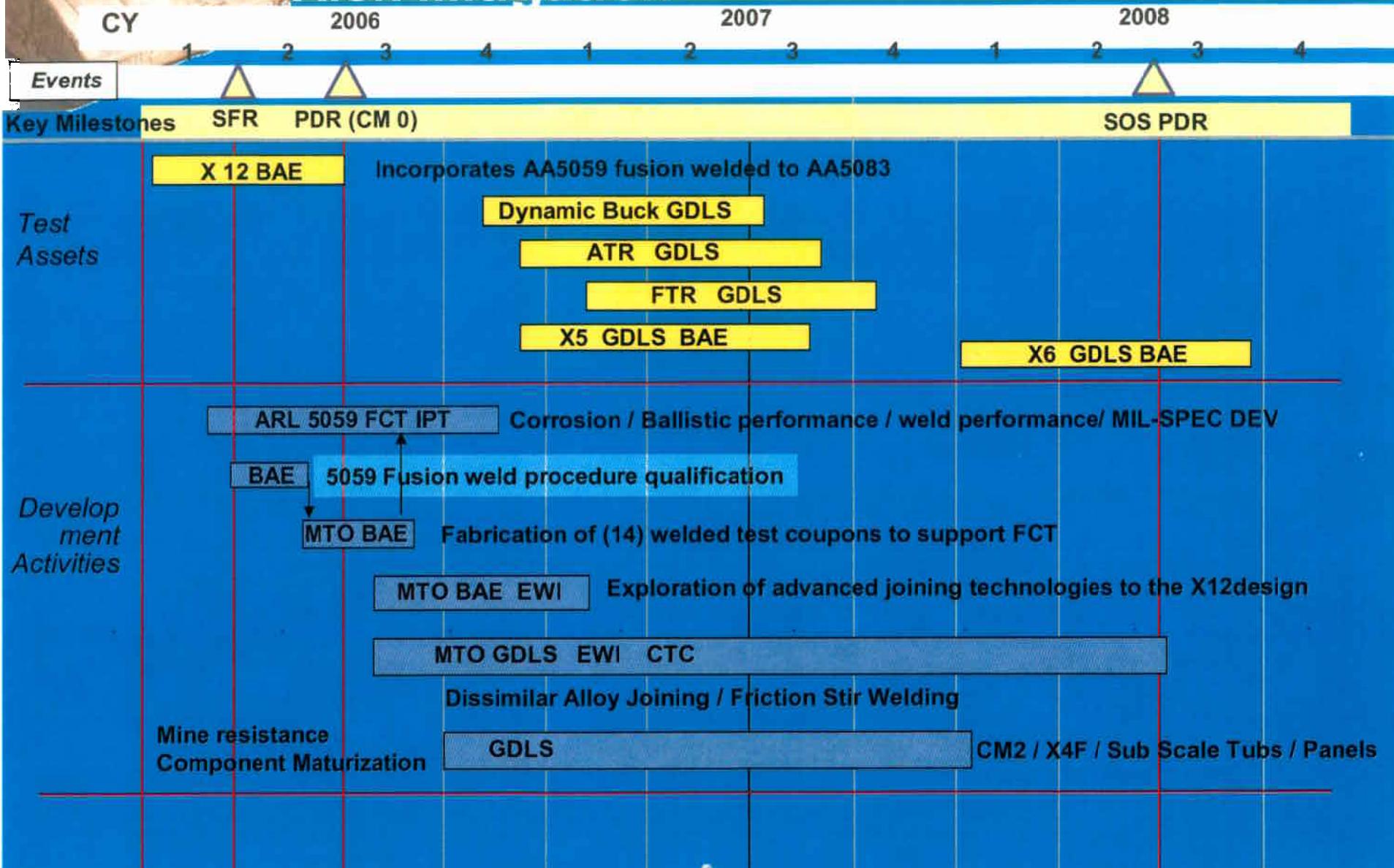
## Hull IPT Development Plan Approach

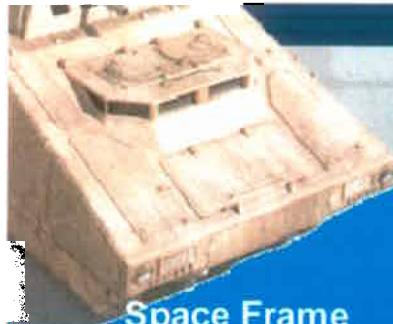
- Baseline hull material – 5059 hull / 2195 belly plate
- Risk fall back alternate plan A – based on possibility that hybrid belly plate technology may not mature prior to PDR
  - Fall back construction #A1- 5059 hull and belly plate
  - Fall back construction #A2- 5059 hull and titanium belly plate
- Risk fall back alternate plan B – based on possibility that 5059 may not mature prior to PDR
  - Fall back construction #B1- 5083 hull / 2195 belly plate
  - Fall back construction #B2- 5083 hull and titanium belly plate





## Risk Mitigation





# Advantages of Structural Approaches

## Space Frame

Lightest "structure only" weight

Tailorable survivability

- Ballistic armor tailored to mission requirements
- Low burden integration of EMA, Signature Management, Etc.

Ease of repair

Improved transportability

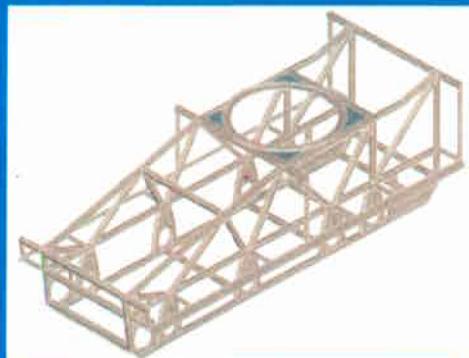
## Monocoque

Lightest weight approach assuming a base level of ballistic protection

Efficient integrated structural armor solutions

Maximum interior volume

Lowest cost

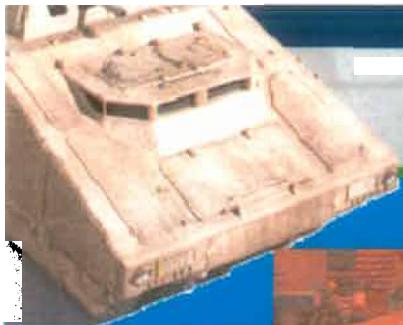


Space Frame

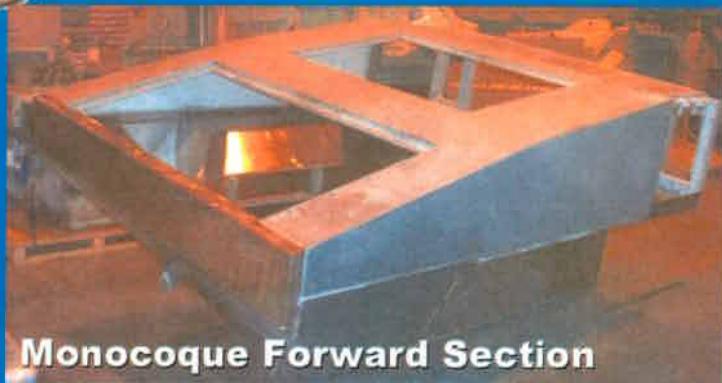
Hybrid Structures

Monocoque

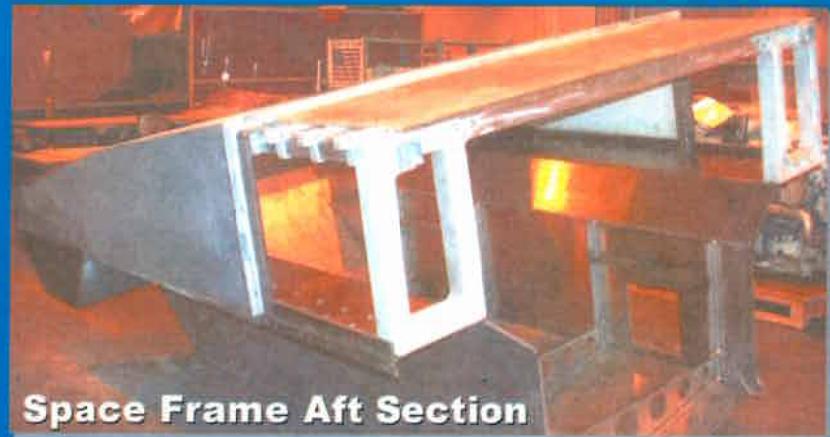




## X1 Ballistic Test Section

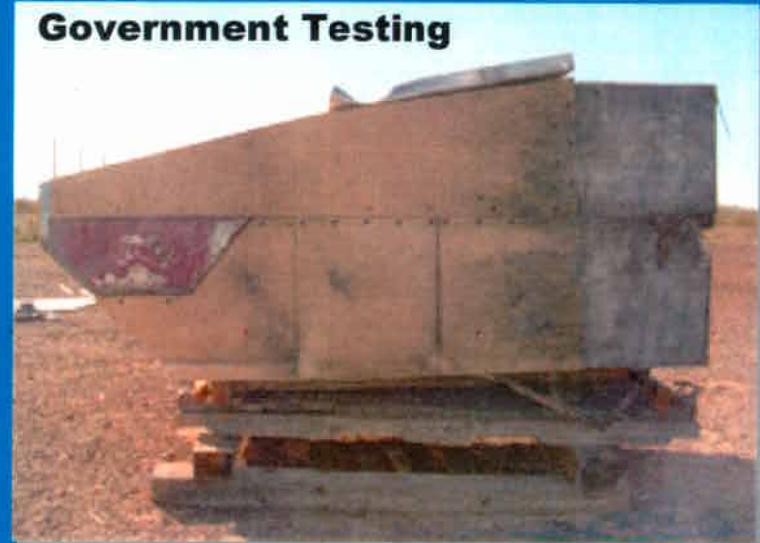


**Monocoque Forward Section**



**Space Frame Aft Section**

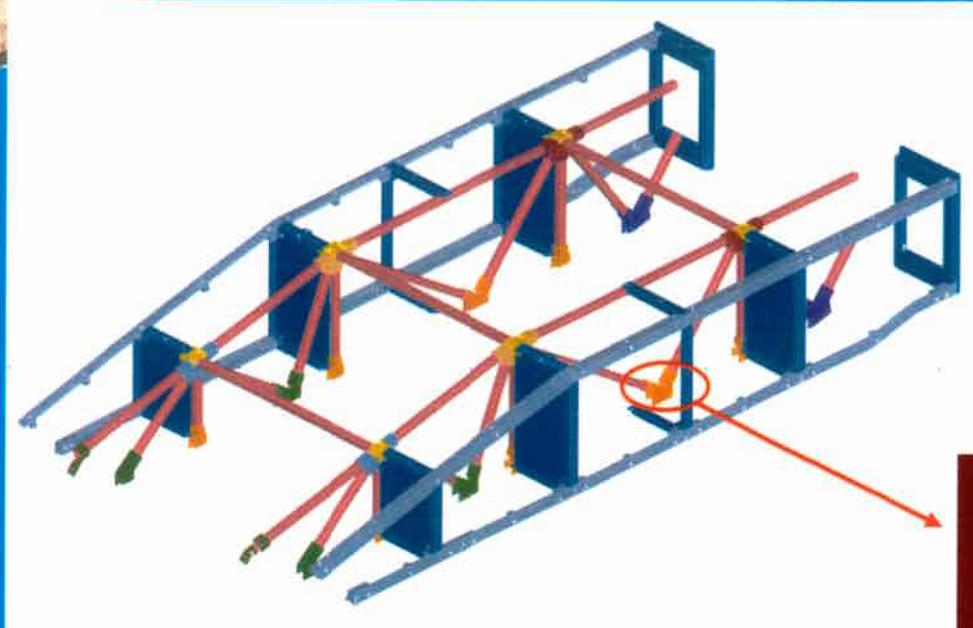
Leverages IHS concept to provide a full-scale hull survivability test bed  
Composite HMG/Frag upper hull  
Metallic lower hull with integral Medium Cannon front and ballistic armor skirts  
Aluminum space frame aft section provides easy installation of modular armor for evaluation  
EMA "integration" demonstrated  
Enough power and energy storage on board to accommodate applique  
Structural "sockets" or access points are designed in



**Government Testing**



## ARES Spaceframe Nodes



Lower Attachment Node Halves

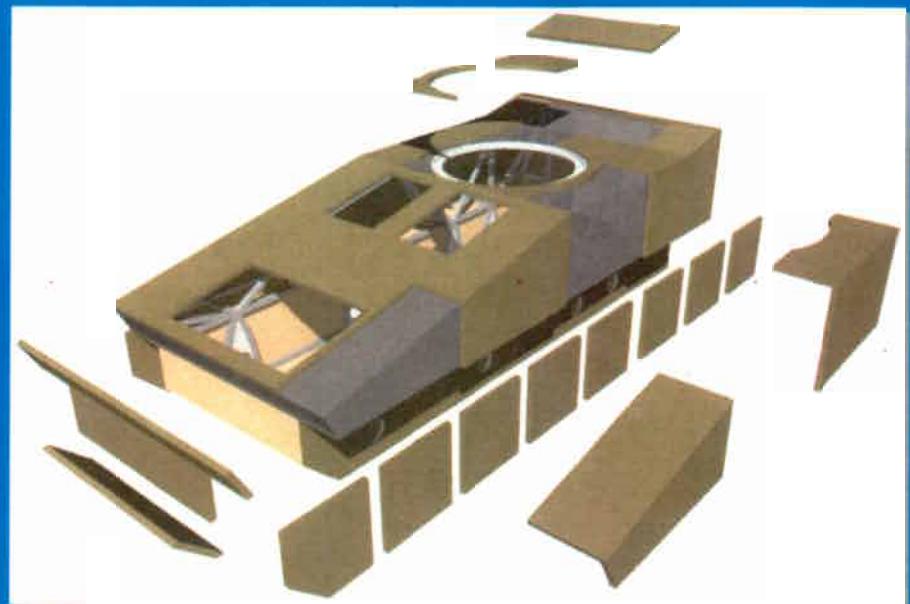




## Selected Space Frame Structure

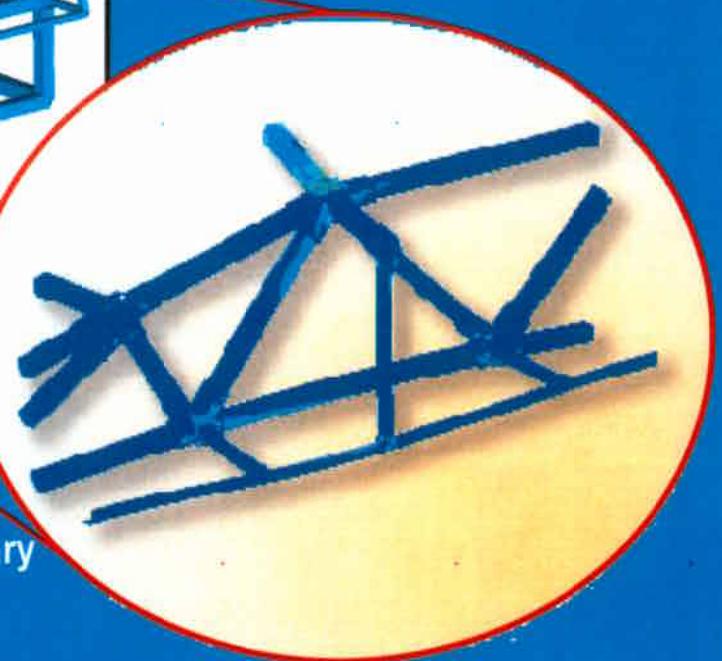
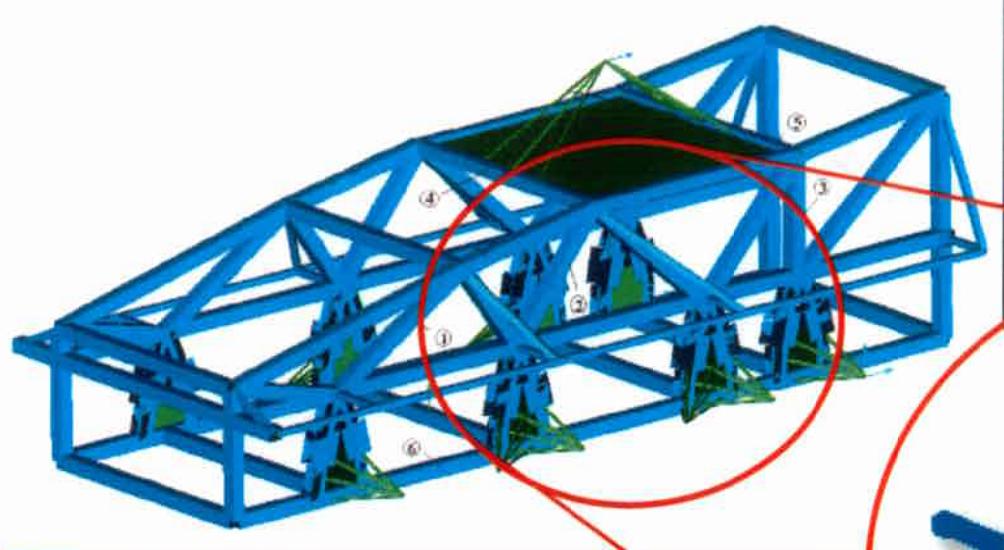
### **Features**

- Full space frame design
- High strength frame
- Composite upper and lower shells for EMI/Environmental
- Base armor mounts to frame
- Add-on armor/survivability kits mount over base armor





## FEA Model



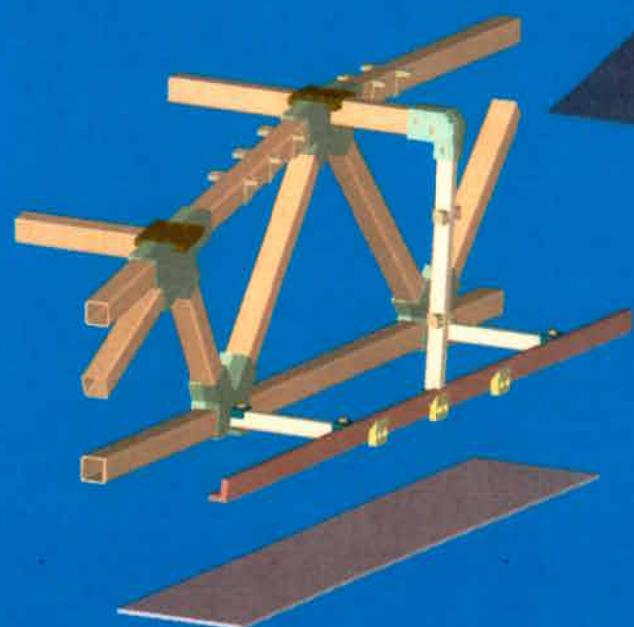
Forces, moments and displacements are extracted from the global model and applied as boundary conditions for local model.

***Little or no redundancy: Sponson framing not required for mobility or gun firing; supplied as practical structure for mounting***



## AX-0 Test Section Components

*Frame Assembly*



*Composite Upper Skin*



*Armor Module*



*Mounting Guides*



***Completed January 2005***

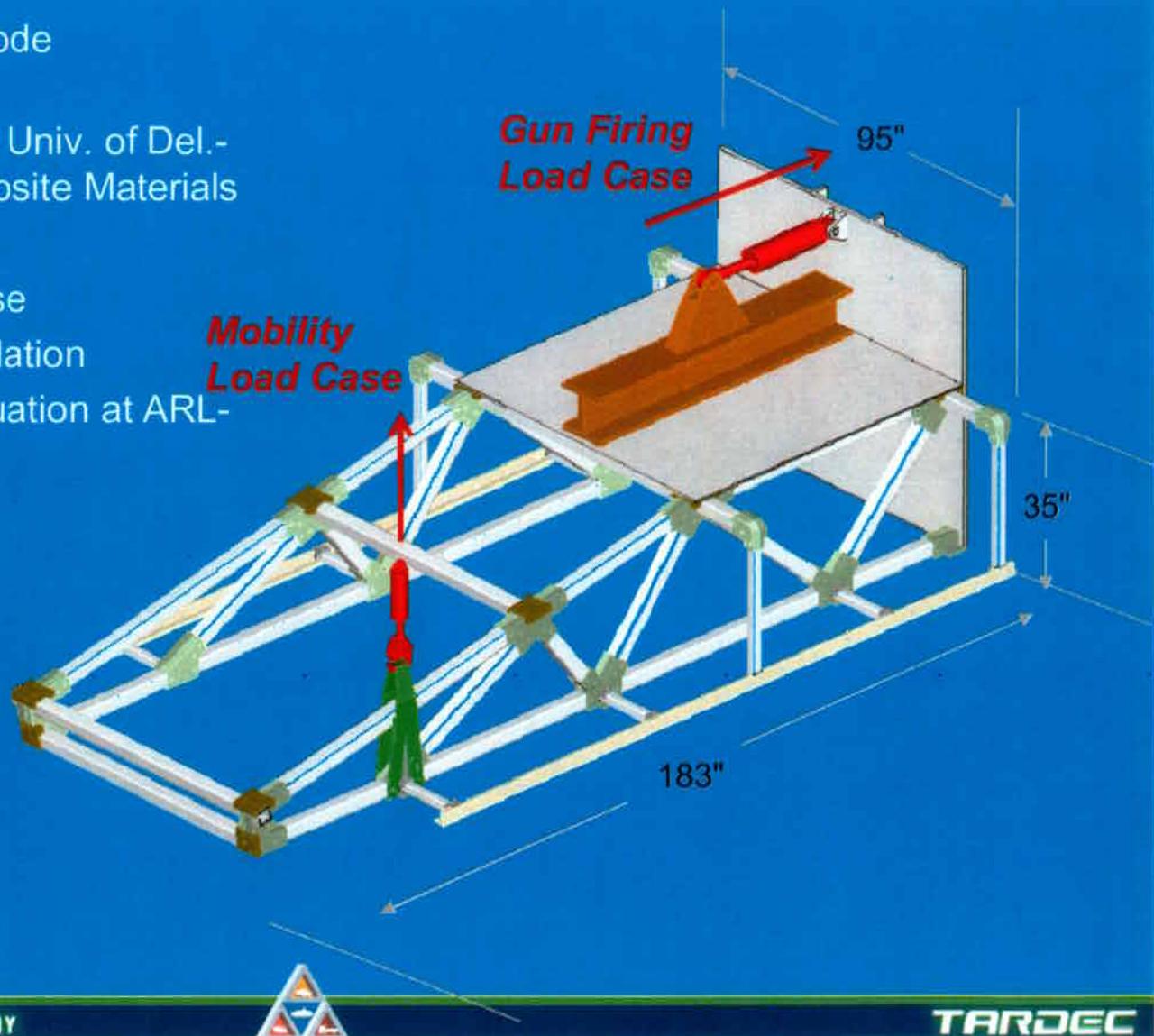




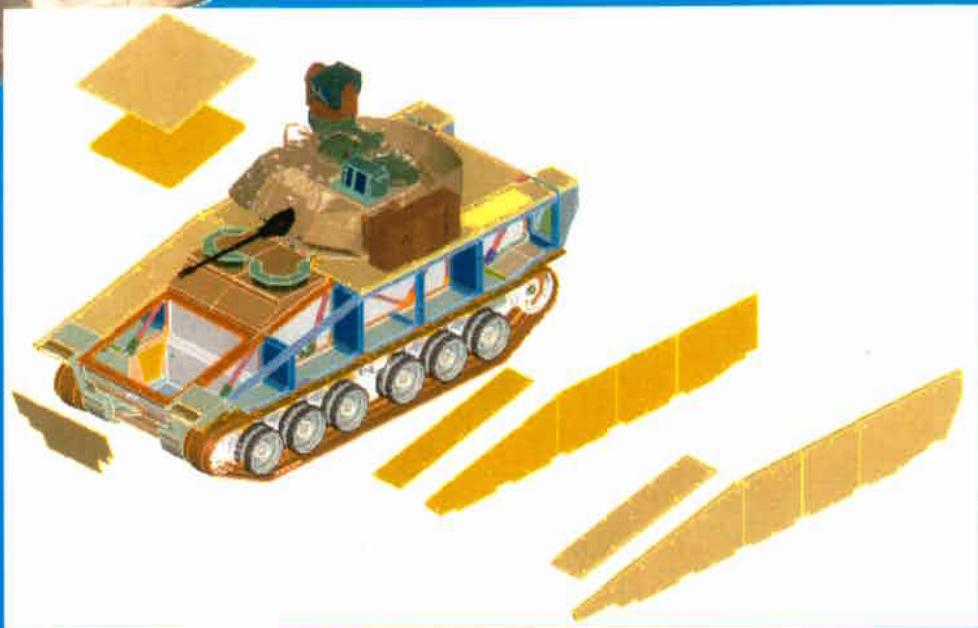
## AX-1 Test Asset

### Features

- Multiple tube and node configurations
- Structural testing at Univ. of Del.- Center for Composite Materials
- Mobility load case
- Gun firing load case
- FE Analysis Correlation
- Ballistic shock evaluation at ARL-Aberdeen



# ARES Layout Option



Left Side – Armor  
suite and skins  
remove or set aside  
for ASC show



Right Side – Armor  
suite and skins attach  
for ASC show

## 25th Army Science Conference

"Transformational Army Science and Technology – Charting the next 50 years of science and technology for the Soldier"

Sponsored by the Assistant Secretary of the Army  
(Acquisition, Logistics and Technology)



November 27 - 30, 2006

JW Marriott Orlando, Grande Lakes Orlando, Florida